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DRYING APPARATUS

Akio Kobayashi

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DRYING APPARATUS

[Kanso sochi]

Inventor:	Akio Kobayashi
Applicant:	KK Pre-tech

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Claim

Drying apparatus characterized in that it is equipped with: a fixed base for affixing the substrate material to be cleaned with ultrapure water, a vibrator disposed on the reverse surface of the fixed base, an oscillator for driving the vibrator, and a nozzle that is disposed above the aforementioned fixed base to blow gas on the surface of the substrate affixed to said fixed base.

Detailed explanation of the invention

This invention relates to an apparatus used for drying of substrates (for example, silicon wafers, which are LSI substrates, or the photomasks used in the LSI element formation process for said wafers) where a high degree of cleanliness is required after washing.

Prior art

For example, silicon wafers used to manufacture semiconductor devices are usually cut [from] silicon ingots, mirror polished, immersed in a processing tank that contains hydrofluoric acid or nitric acid, then washed with ultrapure water, and also submitted for element formation after being dried. These silicon wafers are also subjected to drying after washing with ultrapure water in the process for forming LSI elements, etc.

So as drying apparatuses used after the aforementioned washing with ultrapure water, the structures explained below are already known.

(1) A so-called spin drying apparatus that is equipped with a rotary base that rotates at high-speed. The substrate (wafer, etc) after washing is affixed on said rotary base, the rotary base is rotated at high speed, and the water on the substrate surface is separated and removed to dry it.

(2) A so-called gas knife type cleaning apparatus where a nozzle that has a long, narrow nozzle opening that blows high-pressure gas is disposed above the fixed base, the substrate (wafer, etc.) after washing is affixed on said fixed base, said nozzle is moved over the top of the substrate while high-pressure gas is blown from the aforementioned nozzle, and water on the substrate surface is separated and removed to dry it.

(3) A so-called vapor drying apparatus with a heating means is furnished in a treatment tank that contains isopropyl alcohol (IPA). The substrate (wafer, etc.) after washing is placed in the top part of said treatment tank so that the clean surface faces the IPA on the inside, and the water on the substrate surface is replaced by IPA, which is then vaporized by the heating means, and is removed and dried.

Problems to be solved by the invention

However, with the aforementioned spin drying apparatus in (1), the rotary base is rotated at a high speed of 2000-5000 rpm and the moisture on the substrate on said rotary base is separated and removed. So the problem has been that the flying water strikes the cylindrical hood placed around the periphery of said rotary base and splashes back, and it re-adheres to the substrate surface, causing contamination. Making the distance between the rotary base and the hood large enough to avoid this to prevent the aforementioned substrate contamination has been considered, but this causes a new problem, namely, the apparatus will become bigger. With the aforementioned gas knife type drying apparatus in (2), the problem has been that, not only does the same type of substrate contamination as in aforementioned (1) occur, but static electricity is generated by friction of the high-pressure gas and the substrate, and particles of impurities in the gas adhere to the substrate surface, causing contamination. With the aforementioned vapor drying apparatus in (3), toxic, highly flammable IPA is used, so there would be problems such as

deterioration of the work environment and concerns about fire, and in addition, pollution caused by discharge of used IPA.

This idea was devised to solve the aforementioned problems. It will provide a compact drying apparatus that can sufficiently remove water on the substrate surface to make it highly clean as well as preventing contamination caused by water splash back.

Means to solve the problems

The present invention is a drying apparatus that is characterized in that it is equipped with a fixed base for affixing the substrate material to be cleaned with ultrapure water, a vibrator disposed on the reverse surface of the fixed base, an oscillator for driving the vibrator, and a nozzle that is disposed above the aforementioned fixed base to blow gas on the surface of the substrate affixed to said fixed base.

Operation

With this invention, water on the substrate surface can be removed just by blowing gas from a nozzle at a pressure one magnitude lower than the high-pressure gas in a conventional gas knife type drying apparatus by combining atomizing of the water on the surface of the substrate affixed on said fixed base using a vibrating plate disposed on the reverse surface of the fixed base, and a nozzle disposed above said fixed base to blows gas. The result is that, as already stated, it is possible to obtain a compact drying apparatus that can sufficiently remove water on the substrate surface to provide a high [degree of] cleaning, and also prevent contamination by water splash-back.

Application examples of the invention

Below, an application example of this invention will be explained in detail by referring to Figures 1 and 2.

(1) in the figures is a cylindrical fixed base that has vacuum chuck part (2) at the top. Vacuum tube (3), that communicates with a vacuum pump which is not shown, is connected in the center of the reverse surface of vacuum chuck (2) of fixed base (1). A plurality of vibrators (4), for example, four, is also disposed on the reverse surface of aforementioned vacuum chuck part (2). These vibrators (4) are formed from ceramic piezoelectric elements with a resonating frequency of 800 kHz, for example. Each of the aforementioned vibrators (4) is connected to oscillator (6) by cable (5). In addition, nozzle (7) that can move in the direction of the arrow is disposed above aforementioned fixed base (1). Nozzle (7) is constituted with nozzle unit (8), that is disposed at a desired angle of inclination relative to aforementioned fixed base (1), has a pair of opposing side walls that are tapered and form a rectangular tube shape, and has a long, narrow nozzle opening for

blowing gas (for example, air) to the tip of said tapered part, and gas introduction pipe (9) that is connected to the top wall on the opposite side from the aforementioned nozzle in nozzle unit (8). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned fixed base (1).

Next, the operation for drying a silicon wafer, which serves as the substrate and has been sliced from a silicon ingot, mirror polished, and has water adhered to the surface after washing with ultrapure water, with a drying apparatus constituted as described above will be explained. First, after silicon wafer (1) is mounted on vacuum chuck part (2) of fixed base (1), said wafer (10) is suction chucked by said chuck part (2). Next, vibrators (4) vibrate when 800 kHz high frequency is applied to vibrators (4) through cable (5) from oscillator (6). High-frequency vibration is transmitted to wafer (10), which is vacuum chucked to fixed base (1) with vibrators (4) disposed on the reverse surface, by this, and water (11) adhered to the surface of said wafer (10) is atomized. In this state, when air, for example, is introduced into nozzle unit (8) that is inclined relative to fixed base (1) through gas introduction pipe (9) of nozzle (7) and it is moved and scanned from one end above wafer (10) toward the other end while blowing into the atomized water on wafer (10) from the long-narrow nozzle opening in said unit (8), the atomized water will be removed and drying accomplished. At this time, water (11) adhered to the surface of wafer (10) is atomized by the aforementioned vibrators (4), so air blown toward said wafer (10) through nozzle (7) will remove water (11) on the surface of wafer (10) with pressure (for example, 1-3 m/sec) that is one magnitude or more lower than the high-pressure gas jet (air speed 10 – 30 m/sec) of a conventional gas knife type.

Thus with this invented drying apparatus, water (11) on the surface of wafer (10) can be effectively removed, so wafer (10) can be dried with a high degree of cleanliness. The pressure of the air blown from nozzle (7) can also be lowered, so even when the hood is disposed in a position relatively close to the periphery of fixed base (1), contamination of wafer (10) caused by water that is removed by the blowing of air striking said hood, splashing back, and re-adhering to wafer (10) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the fixed base will be resolved, and it can be made more compact.

Here, with the aforementioned application example, the nozzle was scanned to remove atomized water on the silicon wafer, but the same effect can also be achieved by moving the fixed base.

In addition to the structure shown in Figures 1 and 2, the drying apparatus related to this invention could also be structured as shown in Figures 3 and 4.

That is, (21) in Figure 3 is a rotary base that has vacuum chuck part (22) at the top. Pipe-shaped shaft (23) is connected at the bottom part of rotary base (21). Shaft (23) is supported by bearing (24). It is rotated at a prescribed speed by motor (25), pulleys (26a) and (26b), which

are attached to shaft (23) and the shaft of motor (25), and by timing belt (27), which is pivotally supported on pulleys (26a) and (26b). Multiple suction pipes (28) are inserted inside aforementioned shaft (23). One end of suction pipe (28) is connected to aforementioned vacuum chuck part (22), and the other end is connected to a vacuum pump, which is not shown, through slip ring (29) that is attached to the bottom end of said shaft (23). A plurality of vibrators (30), for example, five, is also furnished on the reverse surface of aforementioned vacuum chuck part (22). The vibrators (30) are formed from ceramic piezoelectric elements with a resonating frequency of 800 kHz, for example. A cable (31) is connected to each of the aforementioned vibrators (30), and each cable (31) is connected to oscillator (32) through aforementioned shaft (23) and slip ring (29). In addition, supply pipe (33) for supplying pressurized gas (for example, air) is furnished above aforementioned rotary base (21). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned rotary base (21).

The drying of a silicon wafer, serving as the substrate that has been sliced from a silicon ingot, mirror polished, and has water adhered to the surface after washing with ultrapure water, by the abovementioned drying apparatus shown in Figure 3 will be explained. First, after silicon wafer (34) is mounted on vacuum chuck part (22) of rotary base (21), the vacuum pump (not shown) connected to vacuum pipe (28) is activated and said wafer (34) is suction chucked to said chuck part (22). Next, when 800 kHz high frequency is applied to vibrators (30) through cables (31) from oscillator (32), vibrators (30) vibrate. High-frequency vibration is transmitted to wafer (34) that is vacuum chucked to rotary base (21), and has vibrators (30) disposed on the reverse surface, and water (35) adhered to the surface of said wafer (34) is atomized. In this state, when motor (25) is activated and rotary base (2) is rotated by pulley (26b), timing belt (27), pulley (26a) and shaft (23) while pressurized air is supplied toward wafer (34) from gas supply pipe (33), atomized water on wafer (34) is removed by the centrifugal force and can be dried. At this time, water (35) adhered to the surface of wafer (34) is atomized by aforementioned vibrators (30), so water (35) on the surface of wafer (34) will be removed by rotary base (21) [rotating] at a speed of rotation (for example, 200-500 rpm) that is one magnitude or more slower than the speed of rotation (2000-5000 rpm) of the rotary base in a conventional spin drying apparatus. The pressurized air supplied from gas supply pipe (33) acts to keep the environment above rotating wafer (34) clean for removing and drying the water adhered to the surface of wafer (34) in this way, so the water on wafer (34) can be removed even if the pressurized gas is not supplied. Thus with the drying apparatus shown in Figure 3, water (35) on the surface of wafer (34) can be effectively removed, so wafer (34) can be dried with a high degree of cleanliness. Also, because the speed of rotation of rotary base (1) can be lowered, even if the hood is disposed relatively close to the periphery of rotary base (21), contamination where the water removed by the centrifugal force produced by the rotation of rotary base (21) strikes said hood and splashes back so that it

re-adheres to wafer (34) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the rotary base will be resolved, and it can be made more compact.

(41) in Figure 4 is a cylindrical fixed base that has vacuum chuck part (42) at the top. Vacuum pipe (43), that communicates with a vacuum pump, which is not shown, is connected to the center of the reverse surface of vacuum chuck part (42) of fixed base (41). A nozzle (44) that can move in the direction of the arrow is furnished above aforementioned fixed base (41). Nozzle (44) is furnished with nozzle unit (45) that is disposed at a desired angle of inclination relative to aforementioned fixed base (41). The pair of opposing side walls of nozzle unit (45), which form a rectangular tube, are tapered, and it has a long, narrow nozzle opening for blowing gas (for example, air) toward the tip of said tapered part. A long, narrow open part is also formed at the top wall on the opposite side from the aforementioned nozzle opening of aforementioned nozzle unit (45), and a vibrator (46) is furnished in said open part. This vibrator (46) is formed from a ceramic piezoelectric element with a resonating frequency of 800 kHz, for example. Aforementioned vibrator (46) is connected to oscillator (48) through cable (47). Gas introduction pipe (49) is connected to the side wall of aforementioned nozzle unit (45). Here, a cylindrical hood, which is not shown, is furnished around the periphery of aforementioned fixed base (41).

The drying of a silicon wafer, serving as the substrate that is sliced from a silicon ingot, mirror polished, and that has water adhered to the surface after washing with ultrapure water, with the abovementioned drying apparatus shown in Figure 4 will be explained. First, after silicon wafer (50) is mounted on vacuum chuck part (42) of fixed base (41), the vacuum pump (not shown) connected with vacuum pipe (43) is activated, and said wafer (50) is suction-chucked to said chuck part (42). Next, when gas (for example, air) is introduced into nozzle unit (45) through introduction pipe (49) of nozzle (44), and 800 kHz high frequency is also applied to vibrator (46) through cable (47) from oscillator (48), vibrator (46) of nozzle unit (45) vibrates, the high-frequency vibration is transmitted to the surface of said wafer (50) using the air blown toward silicon wafer (50) from the long, narrow nozzle opening in said unit (45) as the medium, and the water (51) adhered to the surface is atomized. When nozzle unit (45) is moved from one end above wafer (50) to the other end in this state, atomized water on the surface of wafer (50) can be removed and drying accomplished. At this time, water (51) adhered to the surface of wafer (50) is atomized by the high-frequency vibration using the air from aforementioned nozzle (44) as the medium, so water (51) on the surface of wafer (50) will be removed by the air blown toward said wafer (50) from the nozzle opening of nozzle unit (45) [being] at a pressure (for example 1-3 m/sec) that is one magnitude or greater the high-pressure gas jet (air speed 10-30 m/sec) with a conventional gas knife type. Thus, with this drying apparatus shown in Figure 4, water (51) on the surface of wafer (50) can be effectively removed, so wafer (50) can be dried with a high degree of

cleanliness. Also, the pressure of the air blown from nozzle (44) can be lowered. So even if the hood is disposed in a position relatively close to the periphery of fixed base (41), contamination of wafer (50) due to the water removed by blowing air striking said hood, splashing back, and re-adhering to wafer (50) can be prevented. The result is that making the apparatus larger by disposing the hood at a greater distance from the fixed base will be unnecessary, and the device can be made more compact.

With each of the aforementioned application examples, drying of a wafer that was sliced from a silicon ingot, mirror polished, and washed with ultrapure water was explained, but application in the same way is also possible for drying after washing wafers with ultrapure water in a process for manufacturing a semiconductor device. It is also not limited to silicon wafers, but can be applied in the same way to drying chemical semiconductor materials, for example, GaAs wafers, or InP wafers after washing with ultrapure water, or to drying blank masks themselves or the glass plates that constitute blank masks after washing with ultrapure water. Additionally, application to drying of camera lenses and liquid crystals is also possible.

Effect of the invention

As discussed in detail above, with this invention, it is possible to provide a compact drying apparatus that can sufficiently remove water on a substrate surface to give a high [degree of] cleanliness with this invention, and that can also prevent contamination caused by splash back of water from the hood furnished around the periphery.

Brief description of the figures

Figure 1 is a schematic oblique view of a drying apparatus that shows one application example of this invention. Figure 2 is a schematic cross section of the drying apparatus in Figure 1. Figure 3 or Figure 4 is each a schematic drawing of a drying apparatus that shows another application example of this invention.

(1), (41) ... fixed base, (4), (30), (46) ... vibrator, (6), (32), (48) ... oscillator, (7), (44) ... nozzle, (8), (45) ... nozzle unit, (10), (34), (50) ... silicon wafer, (11), (35), (51) ... water, (21) ... rotary base, (23) ... pipe shaped shaft, (25) ... motor.

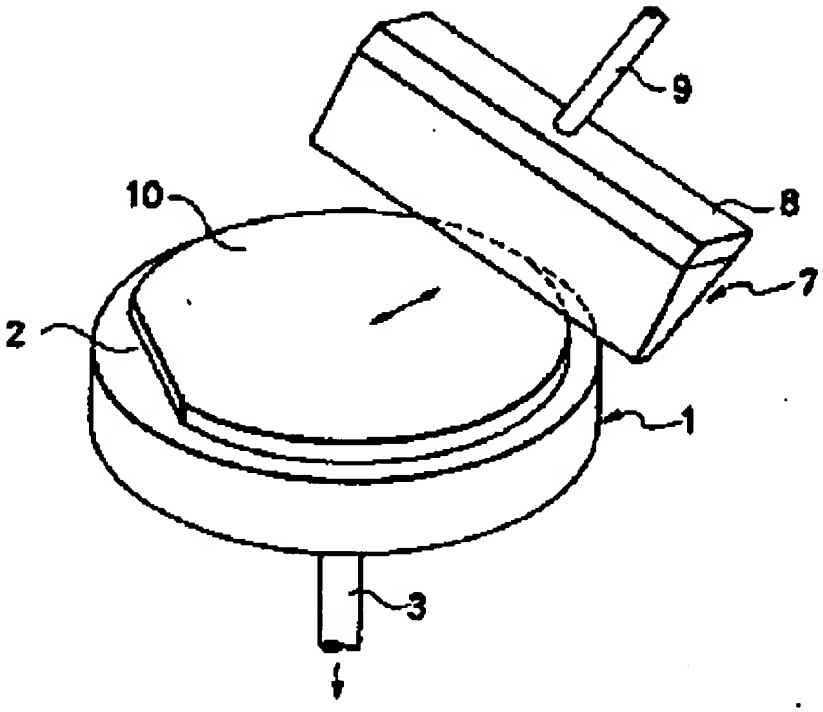

Figure 1

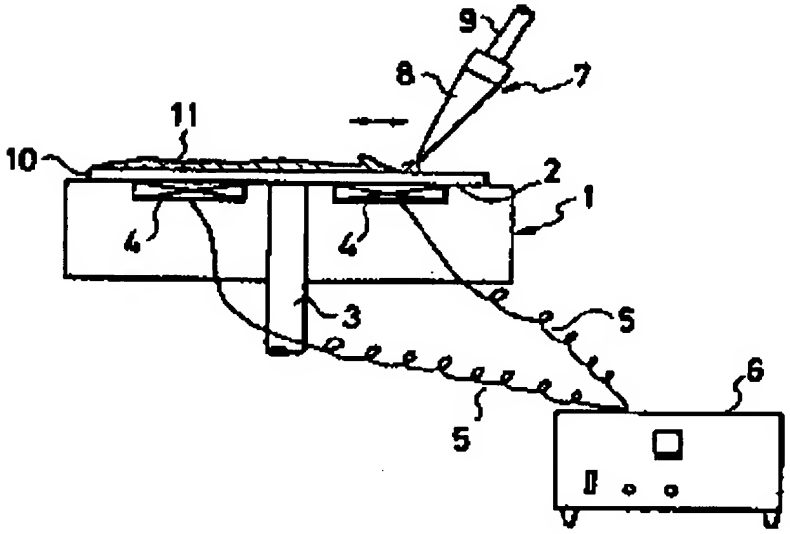

Figure 2

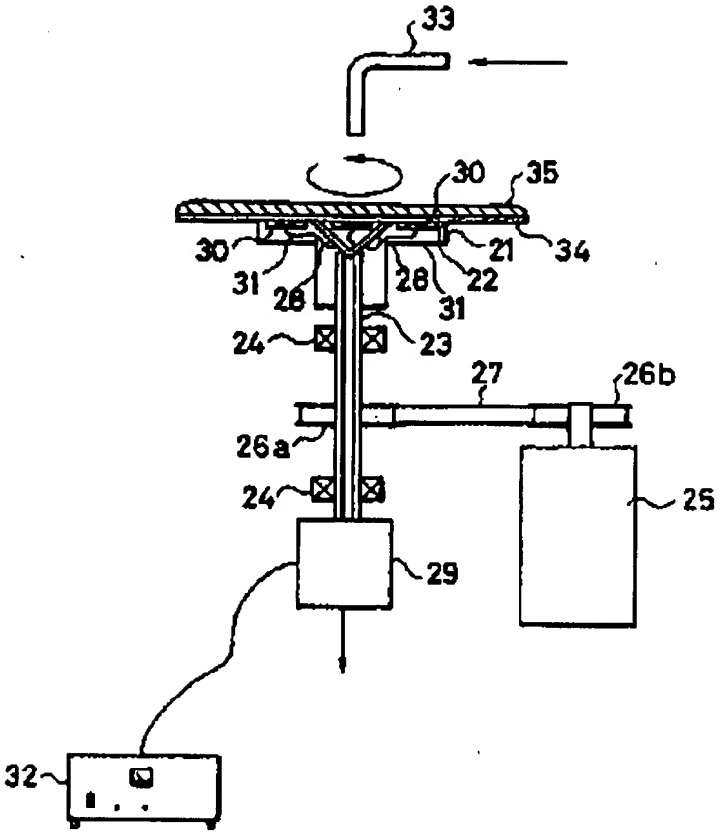

Figure 3

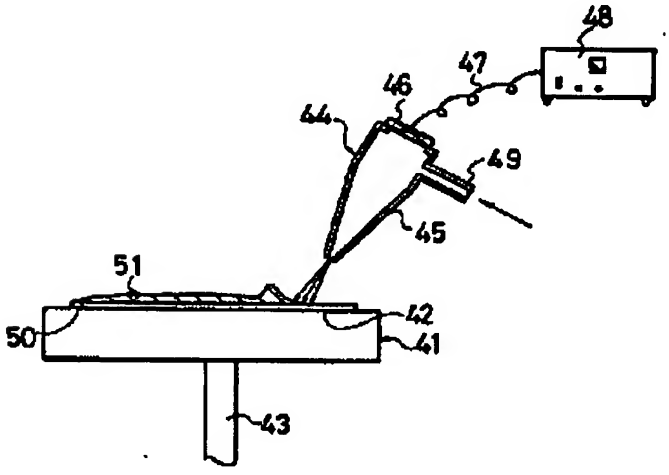

Figure 4